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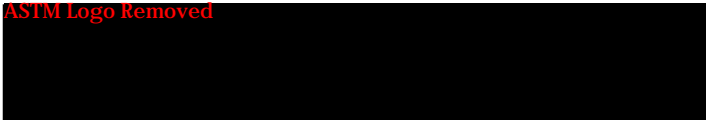


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WASHINGTON, D.C.

Standard Method of Test for SMOKE DENSITY IN THE FLUE GASES FROM DISTILLATE FUELS¹

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ASTM Designation: D 2156 - 65 (Reapproved 1970)

This Standard of the American Society for Testing and Materials is issued under the fixed designation D 2156; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

Scope

1. This method covers the evaluation of smoke density in the flue gases from burning distillate fuels. It is intended primarily for use with home heating equipment burning kerosine or heating oils. It may be used in the laboratory or in the field to compare fuels for clean burning or to compare heating equipment.

Summary of Method

2. A test smoke spot is obtained by pulling a fixed volume of flue gas through a fixed area of standard filter paper. The color (or shade) of the spot thus produced is visually matched with a standard scale,

and the smoke density is expressed as a "Smoke Spot Number."

Significance of Test

3. (a) This method provides a means of controlling smoke production in home heating equipment to an acceptable level. Excessive smoke density adversely affects efficiency by heat exchanger fouling.

(b) The range of smoke densities covered by this method is that which has been found particularly pertinent to home heating application. It is more sensitive to small amounts of smoke than several other smoke tests as indicated in the following comparison:

Smoke Spot Number	Icham, per cent Transmission	Ringelman Smoke Number
0.....	100	0
2.....	95	0
4.....	80	0
6.....	54	0
8.....	18	0
9.....	0	0
9.....	0	0 to 5

¹ Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-2 on Petroleum Products and Lubricants. A list of members may be found in the ASTM Year Book.

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Description of Terms

4. The test result is reported as the "Smoke Spot Number," which is the number of the spot on the standard scale most closely matching the color (or shade) of the test spot.

device and connections shall be of such construction that the total travel of flue gas sample from flue to filter paper shall not exceed 16 in. (40 cm). The device shall provide for cooling the sample below the charring temperature for the

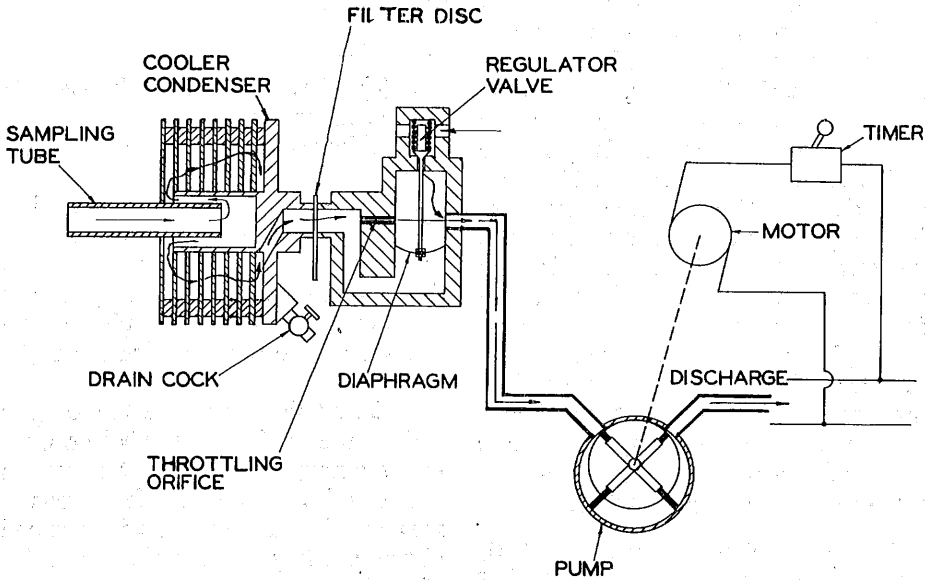


FIG. 1.—Laboratory Type Smoke Meter.

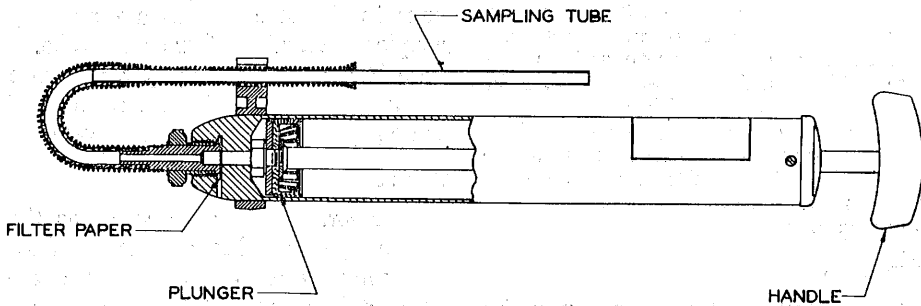


FIG. 2.—Field Service Type Smoke Tester.

Apparatus

5. (a) *Sampling Device.*—A suitable sampling device providing a total volume of 2250 ± 100 cu in. at 60 F, 1 atmos ($36,900 \pm 1650$ cu cm at 16 C, 1 atmos) for each square inch (6.5 cu cm) effective surface area of filter paper. The sampling

filter paper but not below the dew point of the sample. Suitable laboratory and portable field service equipment is illustrated in Figs. 1 and 2.

(b) *Smoke Scale.*—The smoke scale required consists of ten spots numbered consecutively from 0 to 9, ranging in

equal photometric steps from white through neutral shades of gray to black, imprinted or otherwise processed on white paper or plastic stock having an absolute surface reflectance of between 82.5 and 87.5 per cent, determined photometrically. The smoke scale spot number is defined as the reduction (due to smoke) in reflected incident light divided by 10. Thus, the first spot, which is the color of the unimprinted scale, will be No. 0, since in the case of this spot there will be no reduction in reflected incident light directed thereon. The last spot, however, is very dark, reflecting only 10 per cent of the incident light directed thereon; thus in this case the reduction in reflected incident light is 90 per cent, which gives to this darkest spot the No. 9. Intermediate spot numbers are similarly established. Limits of permissible reflectance variation of any smoke scale spot shall not exceed ± 3 per cent relative reflectance (Notes 1 and 2).

NOTE 1.—Such smoke scales are sufficiently accurate for field use and for many laboratory smoke testing applications. However, specially calibrated scales (known as certified smoke scales) will sometimes be required. A certified smoke scale is obtained by individually calibrating each smoke spot of a normal smoke scale.

NOTE 2.—Where the smoke scale is protected with a plastic or transparent cover the construction employed shall be such that when the smoke spot on the filter paper is viewed for matching with the number spots on the smoke scale, both shall be visible through the same thickness and number of sheets of transparent protective cover.

Materials

6. *Test Filter Paper*, made from white filter paper stock having absolute surface reflectance of 82.5 to 87.5 per cent, determined by photometric measurement. When making this reflectance measurement, filter paper must be backed by a white surface having absolute surface reflectance of not less than 75 per cent. When clean air at standard conditions is

drawn through clean filter paper at a rate of 1125 cu in. per min per sq in. (47.6 cu cm per sec per sq cm) effective surface area of filter paper, the pressure drop across the filter paper should fall between limits of 0.5 and 2.5 in. (1.3 and 6.4 cm) of mercury.

Procedure

7. (a) The sampling procedure used is critical. Therefore, the procedure recommended by the equipment manufacturer shall be rigidly followed.

(b) Use a clean, dry, sampling device. If a hand sampler is used, warm it above room temperature to prevent condensation on the filter paper. (This may usually be done conveniently by placing the sampler on the boiler or furnace to be tested.)

(c) Insert filter paper in the sampler and tighten the filter paper holder. Connect the sampling device to the flue gas probe. When taking smoke measurements in the flue pipe, position the end of the sampling probe at the center line of the flue pipe.

(d) Draw the required sample. If a hand sampler is used, permit the pressures in the flue gas stream and the sampler to equalize after each stroke.

(e) Remove the filter paper. Compare the test spot, backed with a piece of white paper, with the standard scale.

Report

8. Report the smoke density as the Smoke Spot Number on the standard scale most closely corresponding to the test spot. Interpolate differences between two standard Smoke Spot Numbers to the nearest half number. Report Smoke Spot Numbers higher than 9 as "Greater than No. 9." (Note 3).

NOTE 3.—Where more accurate results are desired, the human factor involved in visually comparing filter paper test spots with smoke scale spots can be eliminated by resort to direct

use of a suitable photometer for evaluating test spots. This procedure is described in the Appendix.

Precision

9. This test is reproducible to within

$\pm \frac{1}{2}$ of a Smoke Spot Number under normal conditions (Note 4).

NOTE 4.—Normal conditions are defined as those where no oily stain is deposited on the disk.

APPENDIX

ALTERNATE PHOTOMETRIC METHOD

A1. *Direct Photometric Evaluation.*—The human factor involved in visually comparing filter paper test spots with smoke scale spots can be eliminated by resort to direct use of a suitable photometer for evaluating test spots. To make this direct photometric test spot evaluation, the following procedure shall be employed:

Mount filter paper backed by material having absolute surface reflectance of not less than 75 per cent in the light beam of a suitable type of reflectance photometer with beam focused on a clean, unused surface of the filter paper adjacent to the smoke spot. Adjust the photometer to read 100 per cent reflectance in terms of the light reflected from this clean surface. Expose test smoke spot on filter paper to the photometer light beam and measure the percentage re-

duction in reflected light due to the presence of smoke particles on the filter paper. Gross Smoke Spot Number shall be defined as equal to the percentage reduction in reflected light divided by ten.

A2. *Photometer Specifications.*—The photometer to be employed for direct test spot number evaluation shall be of the electrically operated reflectance type employing a photo-electric cell, fitted with a special holder to accommodate filter paper test disks. It is to be furnished complete with green tristimulus filter and with reflectance standards of approximately 20, 40, 60 and 80 per cent absolute reflectance, to permit photometer readings between 10 and 90 per cent (relative to clean filter paper) to be made within ± 2 per cent accuracy.